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Alfalfa as a single dietary source for molt induction in laying hens

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Abstract

Molting is a process by which a hen's reproductive tract is rejuvenated prior to the beginning of a laying cycle. This process is often artificially induced in commercial settings in order to extend the productive life of a flock of hens. The most common method for the induction of molt is feed withdrawal for a period of several days. It has been noted that feed withdrawal, while effective in inducing molt and allowing an adequate reproductive rest period for the hen, may cause deleterious effects on the animal. This has prompted the investigation of alternatives to feed deprivation for the induction of molt in commercial laying hens. This study involved feeding alfalfa to hens to assess its ability to induce molt. Results show that alfalfa meal and alfalfa pelleted diets were equally effective as feed withdrawal in causing ovary weight regression in birds. Molted hens induced by alfalfa diets exhibited post-molt levels of egg production over a twelve week period that were similar to that of hens molted by feed withdrawal. The postmolt eggs laid by hens molted by alfalfa were of comparable quality to eggs from feed deprived hens. Alfalfa, a fibrous feed with low metabolizable energy, may be provided to hens on an ad libitum basis for an effective molt induction that retains comparable egg quality and production.

Keywords: Molting; Egg quality; Alfalfa; Egg production; Laying hen

1. Introduction

In nature, several species of birds self induce a period of fasting known as molting, where they lose up to 50% of their body mass (Mrosovsky and Sherry, 1980). Upon completion of the molting process, the reproductive system is rejuvenated, allowing the bird to enter into an egg production cycle. In commercial systems, this process is often induced in older table egg laying hens to increase egg production. The most widely used method of inducing this molt is by the withdrawal of feed (also referred to as feed deprivation) for a period of several days in order to reach a target weight loss of approximately 25–30% (Bell, 1987; Brake, 1992; Brake, 1993). However, it is becoming more apparent that an alternative to this approach is needed because public awareness of bird stress due to feed deprivation molt induction has increased over the years (Ruszler, 1998). In addition, researchers (Holt, 1999) suggest that molting by feed deprivation leads to greater intestinal colonization by *Salmonella enterica* subspecies enterica serovar Enteritidis (*S. enteritidis*).

Researchers have attempted to find alternatives to feed deprivation that would still provide the same economical benefits to producers while improving the health and stress levels of the animals. Studies have been conducted to ascertain the most effective diet to be given to hens after a period of feed deprivation to allow the hens to recover more quickly (Brake et al., 1979; Koelkebeck et al., 1993). Research has been previously directed towards formulating low energy basal diets that would induce molt

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when fed on a restricted basis (Rolon et al., 1993). Recently, the use of insoluble plant fibers and byproducts have been investigated and successful alternative molt induction diets have been developed from grape pomace, wheat middlings, cottonseed meats and jojoba meal (Vermaut et al., 1998; Seo et al., 2001; Davis et al., 2002; Keshavarz and Quimby, 2002). However, most of these dietary sources are considered essentially waste or feed processing byproducts and not necessarily common feedstuffs that are readily available commercially.

The high quality forage, alfalfa has the potential to serve as a single dietary source for molt induction. Alfalfa is a commercially available feedstuff that is high in protein (17.5%) and crude fiber (24.1%) while exhibiting a relatively low metabolizable energy (1200 kcal/kg) (National Research Council, 1994). In the past, alfalfa has been investigated for use in commercial laying facilities as a means of pigmenting egg yolk (Burdick and Fletcher, 1984; Fletcher et al., 1985; Ganeshan and Kumar, 1989; Guenthner et al., 1973). Alfalfa has also been investigated as a concentrated protein source for poultry (Dale et al., 1984; Miller et al., 1972). It has been previously shown that alfalfa has one of the slowest passage rates in the avian gastrointestinal tract (Sibbald, 1979, 1980). This is extremely advantageous, since dietary fiber sources may be fermentable to some extent by indigenous microorganisms in the gastrointestinal tracts of chickens (Ricke et al., 1982) and a slow passage rate would allow for a greater breakdown of feed and more extensive microbial fermentation. This fermentation could retain microflora that may function, in part, as a barrier to diseases and pathogenic bacteria (Vispo and Karasov, 1997). Preliminary studies in our laboratory have shown that when alfalfa is fed as the fiber source to induce molt, *S.* Enteritidis colonization and infection is limited during the molting period (Kwon et al., 2001). The objectives of this study were to investigate as to whether alfalfa in pelleted or meal form would effectively induce molt and to monitor egg production and quality as the hens entered the early phase (first 12 weeks) of the second cycle of egg production.

2. Materials and methods

A total of 150 White Single Comb Leghorn laying hens aged 70–80 weeks were obtained from a commercial laying facility and birds were placed 1 bird/cage. The hens were provided ad libitum access to a complete layer ration and water for a period of 8 weeks. During this time, egg production was monitored to insure that all hens were healthy and in active production. After the acclimation was complete, 116 hens were moved to different cages (placed 2/cage) for the molting procedure. Hens were divided into one of four treatment groups with: Alfalfa meal (28 birds), alfalfa pellet (28 birds), layer ration (non-molted control, 28 birds) and feed withdrawal (negative control, 32 birds). All birds were allowed ad libitum access to water and their respective diets. Birds were placed on a lighting program of 8 h light:16 h dark for one week prior to the beginning of the molt (Holt et al., 1994). Birds were placed throughout the house to ensure there was no variability in egg production or reproductive tract regression due to light stimulation.

Premolt egg quality data was also collected during the acclimation period. These egg quality data included exterior egg quality, albumen thickness, size of air cell, egg dimensions and interior egg quality. Exterior egg quality was graded according to USDA standards (USDA, 1995). Eggs were candled to determine thickness of the albumen and size of the air cell. Egg dimensions such as weight (g), circumference (cm), and length (cm) were determined. Interior quality including albumen height (mm) and yolk height (mm) was also measured.

During the molt, bird weights were monitored at day 1, 3, 5, 7, and 9. In accordance with standard animal use protocols, any hens reaching 25% weight loss prior to the end of the trial (day 9) were removed from their respective diet. At the end of the molt, 58 birds were sacrificed and their reproductive tracts weighed. The remaining 57 birds (alfalfa meal,14 birds; alfalfa pellet, 14 birds; layer ration, 13 birds; and feed withdrawal, 16 birds, after mortalities and sacrifice for ovarian measurements) were provided layer ration on an ad libitum basis. The light program was changed to 16 h light:8 h dark to stimulate egg production. All egg parameters were monitored for 4 weeks after the end of the molting period. Egg production was monitored for 12 weeks after the end of the molting period. Due to additional mortalities in the postmolt period, hens for the last 8 weeks of egg production consisted of 13 birds that had been previously molted by alfalfa meal; 14 birds for alfalfa pellet; 12 birds for layer ration; and 14 birds for feed withdrawal.

2.1. Statistical analysis

This study was constructed as a completely randomized design. One way analysis of variance (ANOVA) was performed on all parameters. Mean separation was assessed using the Duncan test. Significance implies a probability value of $p < 0.05$. All statistical analyses were compiled using SAS version 8.0 (2000).

3. Results

3.1. Body mass and ovarian weight

All treatments exhibited significant differences ($p < 0.05$) in percent body mass lost in this study. Feed

Table 1
Laying hen body and ovary weight response to molting and non-molting diets

Molt treatment	Weight lost (%)	Ovary weight (g)
Feed deprivation	23.3 ± 0.63[a]	6.2 ± 1.23[b]
Alfalfa meal	18.9 ± 1.39[b]	5.1 ± 0.49[b]
Alfalfa pellet	15.2 ± 1.54[c]	7.0 ± 1.90[b]
Unmolted	+2.3 ± 0.65[d]	36.5 ± 4.63[a]

[a–d] Denotes statistically different findings within columns ($p < 0.05$). Average values are reported with ± the standard error.

withdrawal hens lost the most mass (23.3%), while alfalfa meal and pellet hens lost 18.9% and 15.2%, respectively (Table 1). In contrast to molted birds, hens fed layer ration (unmolted) gained 2.3% of body mass. Hens fed alfalfa in both pellet (7.0 g) and meal (5.1 g) form did not have significantly different ovarian weights when compared to hens that were feed deprived (6.2 g) ($p > 0.05$). Unmolted hens fed layer ration had a significantly higher ($p < 0.05$) ovarian weight than all of the molted hen treatments. The ovaries from unmolted hens had a mean weight of 36.5 g (Table 1).

3.2. Egg quality and weight response

Yolk height, egg length, and egg circumference values were not significantly different ($p > 0.05$) across all treatments. The values are summarized in Table 2. Egg length and circumference values remained virtually unchanged when pre- and postmolt data were compared (premolt data not shown). Egg weight and quality responses to molting diets are shown in Table 3. Eggs laid by hens molted with alfalfa pellets (70.1 g) weighed significantly more than eggs laid by hens molted by feed withdrawal (65.3 g) or alfalfa meal (65.6 g). Eggs laid by unmolted hens (68.3 g) were not significantly different from any of the treatments (Table 3). Air cell values were quantified using a scale where AA = 3, A = 2, B = 1, Loss = 0. Hens molted by alfalfa meal (2.98) had a significantly higher ($p < 0.05$) air cell grade than unmolted hens (2.71). Hens molted by alfalfa pellet (2.91) or feed deprivation (2.83) did not have air cell grades that were significantly different ($p > 0.05$). Eggs laid by hens fed alfalfa meal had an albumen height (6.21 mm) that was significantly higher than unmolted hens (5.28 mm). Eggs laid by hens that were feed deprived (5.89 mm) and molted using alfalfa pellets (6.07 mm) did not have an albumen height that was significantly different from either feed deprived or unmolted hens (Table 3).

Table 2
Egg quality response to molting and non-molting diets

Molt treatment	Length (cm)	Circumference (cm)	Yolk height (cm)
Feed deprivation	6.31 ± 0.1[a]	14.33 ± 0.09	17.49 ± 0.5
Alfalfa meal	6.49 ± 0.08	14.28 ± 0.1	17.61 ± 0.65
Alfalfa pellet	6.49 ± 0.07	14.52 ± 0.1	17.65 ± 0.65
Unmolted	6.43 ± 0.06	14.53 ± 0.14	17.23 ± 0.32

[a] Averages values are reported with ± the standard error.

Table 3
Egg weight and quality response to molting and non-molting diets

Molt treatment	Weight (g)	Air cell grade	Albumen height (mm)
Feed deprivation	65.3 ± 1.27[b]	2.83 ± 0.100[a,b]	5.89 ± 0.32[b]
Alfalfa meal	65.6 ± 0.94[b]	2.98 ± 0.015[a]	6.21 ± 0.26[a]
Alfalfa pellet	70.1 ± 1.48[a]	2.91 ± 0.083[a,b]	6.07 ± 0.28[a,b]
Unmolted	68.3 ± 1.90[a,b]	2.71 ± 0.077[b]	5.28 ± 0.17[b]

[a–d] Denote statistically different findings within columns ($p < 0.05$). Average values are reported with ± the standard error.

3.3. Egg production and date of reentry

Postmolt egg production and date of reentry into second egg laying cycle are shown in Table 4. Unmolted hens fed layer ration had a significantly higher level of egg production (61.1%) than hens molted by feed deprivation (44.6%) 0–7 weeks after the molt. While hens molted by alfalfa pellet (50.5%) or alfalfa meal (49.1%) did not have significantly different levels of egg production from either feed withdrawal or unmolted hens, it appeared that both of the treatments exhibited somewhat higher mean egg production than feed deprived hens. It should also be noted from an examination of egg production values presented in Fig. 1 that these hens appeared to rebound more quickly in the first few weeks after molting than feed deprived molted hens.

Unmolted hens (68.0%) and hens molted by alfalfa pellet (77.1%) showed no significant difference in egg production from 8 to 12 weeks after the molt (Table 4). Hens fed alfalfa meal (83.4%) yielded significantly higher egg production levels than hens molted by feed deprivation (70.6%) and unmolted hens. In the weekly analysis of egg production (Fig. 1), it appears that hens molted by alfalfa diets continued to increase egg production for up to 12 weeks postmolt. Hens molted by alfalfa pellet (11.6 days) reentered production significantly faster than hens that were molted by feed deprivation (17.3

Table 4
Egg production postmolt and date of first oviposition

Molt treatment	0–7 Week (%)	8–12 Week (%)	Date of reentry (# of days)
Feed deprivation	44.6 ± 4.96[b]	70.6 ± 4.37[b]	17.3 ± 1.63[b]
Alfalfa meal	49.1 ± 4.08[a,b]	83.4 ± 2.75[a]	14.0 ± 0.89[a,b]
Alfalfa pellet	50.5 ± 3.90[a,b]	77.1 ± 4.45[a,b]	11.6 ± 0.68[a]
Unmolted	61.1 ± 3.49[a]	68.0 ± 4.59[b]	N/A[1]

[a,b] Denotes statistically significant differences within columns ($p < 0.05$). Averages values are shown ± standard error.
[1] N/A = Non-applicable.

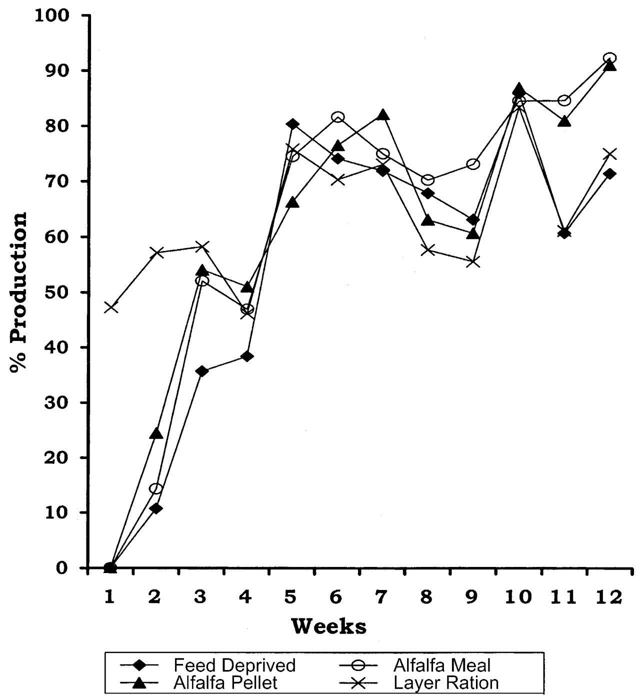

Fig. 1. Percent hen–day egg production by four treatments on a weekly basis both during the molt and during the postmolt.

days). Hens molted by alfalfa meal did not exhibit a significant difference in the onset of egg production (14 days).

4. Discussion

The decision to molt laying hens for a second egg laying cycle is based on the price of eggs versus the cost of feed and replacement pullets (North and Bell, 1990). Generally, induced molting is economically advantageous, especially when factors are included such as the declining value of Leghorn hen carcasses and availability of fewer processors willing to process them as well as fluctuating egg prices and feed costs (Webster et al., 1998; Holt, 1999; McDaniel and Aske, 2000). Compared to unmolted birds, molted birds have increased productivity, better feed efficiency and decreased mortality (Lee, 1982; Alodan and Mashaly, 1999). Molting therefore appears to have a beneficial effect on individual hen performance and an overall flock management advantage of having synchronized hens for a second laying cycle (Lee, 1982). Feed withdrawal is the primary method used in the layer industry to induce molting and stimulate multiple egg-laying cycles in hens but has become problematic due to *S.* Enteritidis infestation problems and animal stress concerns (Bell, 1987; Brake, 1992;Brake, 1993; Ruszler, 1998; Holt, 1999). Alternative high fiber containing molting diets that do not require feed deprivation have been demonstrated to be effective in limiting *S.* Enteritidis infection in molting hens (Holt, 1999; Seo et al., 2001; Kwon et al., 2001). However, for high fiber alternative molting diets to be commercially accepted by the poultry industry they must provide a the molt induction stimulus substantial enough to cause sufficient reproductive tract regression during the molt and yield egg production and quality parameters in the second egg laying cycle that are at least comparable to those typically achieved with feed withdrawal.

Results of the present study show that hens molted over a nine day period with either a 100% alfalfa meal or pelleted alfalfa had regressed ovary weight regression equivalent to hens undergoing feed withdrawal indicating that a sufficient reproductive rest period for commercial laying hens could be achieved. This is consistent with the observation by Seo et al. (2001) that complete cessation in egg production occurred within seven days for birds molted with a wheat middling diet or after undergoing feed withdrawal. In addition, both hens fed alfalfa either in meal or pellet form yielded comparable egg quality values for postmolt eggs. This indicates that alfalfa could be processed either in meal form or in larger particulate fractions and effective molt induction properties would be retained. However, hens molted with pelleted alfalfa exhibited a slightly earlier reentry date for initiation of egg production than hens molted with alfalfa meal. This may be linked to potential compositional changes occurring during the heat treatment processes involved in the pelleting of the alfalfa. Alfalfa molting does appear to offer specific advantages over feed withdrawal hens as alfalfa-induced molted birds exhibited less body weight loss. However, before this can be confirmed collection and weight of intestinal tracts is warranted in future studies to see if the lesser amounts of weight loss in alfalfa molted hens is due in part to presence of alfalfa in the intestinal tract. Hens fed alfalfa exhibited levels of egg production over a 12 week period that were at least comparable to that of hens molted by feed withdrawal. The eggs laid by hens molted with alfalfa were also of comparable quality to eggs from feed withdrawal hens. Davis et al. (2002) also observed equivalent egg production in birds molted with cottonseed meats when compared with egg production over a 50 day period after resumption of egg production.

In conclusion, alfalfa as a single molt induction dietary source appears to meet several of the commercial criteria for successively inducing molt and subsequently retaining egg production and quality during postmolt. Alfalfa offers several advantages as a potential molt diet over other proposed low energy diets because it is readily available in most egg and poultry producing regions of the US as a common high quality forage fed to dairy cattle to achieve high protein levels for maximizing milk production. In addition, alfalfa cubes and alfalfa meal are commonly available as high quality commercial horse feeds. However, several key issues remain with alfalfa molt diets before commercial implementation can be recommended on a scientific basis. Although low energy high fiber diets appear to be relatively effective in limiting *S.* Enteritidis colonization (Seo et al., 2001; Kwon et al., 2001) maximizing gastrointestinal bacterial fermentation activities antagonistic to pathogen colonization with a low energy source such as alfalfa diet may require additional fermentable energy supplementation in the diet. This will require determination of an energy level sufficient to retain fermenting microflora without altering the molt induction properties of the diet. Second, as animal welfare concerns directed towards feed withdrawal molting rise, alternatives such as the alfalfa diet must be screened for potential to alleviate animal stress during molting. In addition, the molting approach in this study was conducted as a relatively short molt induction period of nine days before returning to full layer ration. It would be of commercial interest to examine longer molt periods than nine days as well as incorporating a recovery maintenance diet period prior to returning to full egg production. Finally, although our purpose in the current study was simply to compare molting effectiveness and early postmolt performance of hens fed alfalfa, longer periods of postmolt egg production will need to be examined in future studies to determine long term effectiveness of alfalfa-based molt diets over typical commercial egg laying cycles. Once these issues have been resolved ad libitum feeding of alfalfa may be useful to commercial laying facilities as an alternative flock management strategy for molt induction.

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